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CONVERSION OF GRAPHICAL TO NUMERICAL DATA WITH WEB PLOT DIGITIZER IN OIL RESERVE DETERMINATION

Lia Yunita[1*]; Edy Sunardi[2]

Petroleum Engineering[1]
Universitas Proklamasi 45, Yogyakarta, Indonesia[1]
https://www.up45.ac.id[1]
yunitalia@up45.ac.id[*]

Geological Engineering[2]
Universitas Padjajaran, Sumedang, Indonesia[2]
https://www.unpad.ac.id/[2]
edy.sunardi@nupad.ac.id

(*) Corresponding Author
(Responsible for the Quality of Paper Content)

Abstract— *Old oil fields that are to be reactivated have production data only in graphical form, making it difficult to determine remaining reserves. Web Plot Digitizer helps convert graphical data into numerical data for determining oil reserves using the decline curve method. The use of Web Plot Digitizer reduces numerical errors, which impact decline parameters (qi, Di, b) and time efficiency in reserve determination. The purpose of this study is to apply Web Plot Digitizer to convert graphical production data into numerical data and determine oil reserves using decline curve analysis. The novelty of this research lies in the use of digitized graph data as direct input in Decline Curve Analysis (DCA) analysis for oil reserve estimation. The purpose of this research is to apply Web Plot Digitizer in converting production graph data into numerical data, as well as determining oil reserves using decline curve analysis. This research method uses exponential Decline Curve Analysis (DCA), which is applied to old oil fields, production rate data in the form of graphs is converted into numerical data using Web Plot Digitizer. The digitized numerical data is then made into a semilog graph of production rate versus time, then a trend line is taken for the decline in oil production rate and used in determining oil reserves. The analysis results obtained an initial decline rate (Di) value of 0.041 per month and oil reserves are estimated at 5 million barrels of oil (5 MBO), where oil will be exhausted in January 1985 if no workover is carried out. The results of this analysis provide a solution for old oil fields that only have historical graphs without access to numerical data, so that they can still calculate reserves using Decline Curve.*

Keywords*: Decline Curve, Reserve, Web Plot Digitizer*

Intisari—*Lapangan minyak tua yang akan di reaktivasi mempunyai ketersediaan data produksi dalam bentuk grafik saja, mengalami kesulitan dalam penentuan cadangan sisa. Web Plot Digitizer membantu konversi data grafik kedalam numerik dalam penentuan cadangan minyak dengan metode decline curve. Penggunaan web plot digitizer mengurangi kesalahan numerik (error), yang berdampak terhadap parameter decline (qi, Di, b) dan efisiensi waktu dalam penentuan cadangan. Kebaruan penelitian terletak pada pemanfaatan data hasil digitasi grafik sebagai input langsung dalam analisis Decline Curve Analysis (DCA) untuk estimasi cadangan minyak.. Tujuan penelitian ini, penerapan Web Plot Digitizer dalam konversi data grafik produksi menjadi data numerik, serta menentukan cadangan minyak menggunakan decline curve analisis. Metode penelitian ini menggunakan Decline Curve Analysis (DCA) eksponensial, yang diterapkan pada minyak lapangan tua, data laju produksi berupa grafik dikonversi kedalam data numerik menggunakan bantuan Web Plot Digitizer. Data numerik hasil digitasi kemudian dibuat grafik semilog laju produksi versus waktu, kemudian diambil trend line penurunan laju produksi minyak. dan digunakan dalam penentuan cadangan minyak. Hasil analisis didapatkan nilai initial decline rate (Di) sebesar 0,041 per bulan dan cadangan minyak diperkirakan 5 juta barel minyak (5 MBO), dimana minyak akan habis pada bulan Januari 1985* *apabila tidak dilakukan workover. Hasil analisis ini memberkan solusi terhadap lapangan minyak tua yang hanya memiliki grafik historis tanpa akses ke data numerik, sehingga tetap dapat melakukan perhitungan cadangan menggunakan Decline Curve.*

Kata Kunci*: Kurva Penurunan, Cadangan, Web Plot Digitizer*

INTRODUCTION

Determining oil reserves is a crucial aspect of field development planning and economic decision making in the oil and gas industry. One of the most commonly used methods for reserve estimation is Decline Curve Analysis (DCA), which utilizes historical production rate data to predict future production performance. However, in practice, the availability of complete numerical production data is often a constraint, particularly in mature fields where information is only presented graphically. The main problem in this study is the unavailability of numerical production data that can be directly used for DCA analysis, thus limiting the oil reserve estimation process. Decline Curve Analysis is based on the mathematical relationship between production rate and time. One of the simplest and most widely used forms is exponential DCA, which assumes a constant rate of production decline with time, as shown in equation 1. In the context of limited numerical data, Web Plot Digitizer becomes a relevant tool because it is able to systematically convert graphical data into numerical data.

This tool allows the extraction of data points from production graphs so that they can be reused for quantitative analysis. The relevance of this approach to oil reserve determination studies lies in its ability to bridge the gap between graphical data and the need for numerical data in DCA analysis. The novelty of this study lies explicitly in the integrated application of Web Plot Digitizer as the main data source in exponential Decline Curve Analysis for oil reserve determination. This study shows that the digitized data from the graphs can be used directly in DCA parameter calculations and reserve estimation, thus opening up opportunities for reusing historical production data that was previously limited to graphical representations.

The emergence of Artificial Intelligence (AI) in the oil industry has increased its use in exploration, development, production, reservoir engineering, and management planning, accelerating decision-making and reducing costs and time[1] .The use of "Big Data" and the use of Artificial Intelligence (AI) are currently growing due to the increasing and increasingly affordable capabilities of data collection and processing. Machine and Deep Learning (ML/DL) is a subtype of AI, which is gaining high interest in the data science and engineering community worldwide [2] The use of Web Plot Digitizer v4.2 in scaffold engineering and permeability research to extract graph data from previously published publications. The data were used for fitting a Forchheimer model, demonstrating that the tool supports accurate calibration and annotation of data points from graphs of fluid engineering experiments [3].

Research in estimating the normalized friction torque of a joint on an industrial robot manipulator using the WebPlotDigitizer tool to obtain numerical data[4]. Web Plot Digitizer extracted elevation profiles and trip durations from Google Maps. The data was then processed into charge cycles and used in a battery degradation model[5] PlotDigitizer can be an alternative to other programs because it is free and can be run on many current and outdated systems, and is valid and reliable because it is almost perfect [6]. One of the commonly used methods for oil reserve estimation is Decline Curve Analysis (DCA), which relies on historical production data to project future production and calculate Estimated Ultimate Recovery (EUR). Decline Curve Analysis is a method used to predict future production from oil or gas wells based on past production data. This method assumes that production will decline over time and can be predicted using mathematical models. The three main models used in DCA are exponential, hyperbolic, and harmonic models.

The selection of the appropriate model depends on the reservoir characteristics and available production data. For example, a case study of the Semutang gas field showed that the hyperbolic model provides more realistic production projections than the exponential and harmonic models [7][8]. Remaining reserves, also known as Remaining Reserves, occur when a well is already producing and flowing. Production well data can be used to determine when the well will no longer be productive using the Decline Curve Analysis method. This method is used to calculate the Q limit. This aims to periodically calculate the estimated remaining oil reserves and predict future production times from a reservoir. This well is a natural flow well, so it can be used to determine the limits of a well using the decline curve method [9]. Gaussian model to analyze the production of hydraulically fractured wells in the Midland Basin, Texas. This model offers a more realistic approach compared to traditional exponential models, particularly in depicting the

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high initial production and rapid decline in these wells. Developing a tight gas well production prediction model that combines DCA with an artificial neural network (ANN).

This model is capable of predicting short-term production with high accuracy, overcoming the limitations of traditional DCA models that often do not consider data variability and uncertainty [10] Analyzed over 30,000 shale oil wells across three major formations in the US, identified the most appropriate DCA model for production prediction and reserve estimation, and integrated machine learning into DCA for gas condensate wells with complex production histories due to new reservoir perforations, improving the accuracy of production forecasting and reserve estimation[11] Oil reserves were determined using Excel using the decline curve analysis (DCA) method. Arps' (1945) method has three types for analyzing production decline [12]

$$q(t) = q_i \times e^{-Di \times t} \quad (1)$$

Where:
q(t) = production rate at a certain time
qi = initial production rate
Di = initial decline rate (initial decline per time)
b = exponential decline ($0 \le b < 1$)
t = production time

The type of decline curve needs to be determined first before estimating the remaining oil reserves and the age of the reservoir that is still producing until it reaches the minimum production rate limit (q limit). The curve pattern between production rate (q) and time (t) can be predicted mathematically. According to Arps, J.J. (1945), there are three types of decline curves based on their curvature, namely: a). Exponential Decline, b). Harmonic Decline, and c).. Hyperbolic Decline[13]
There are two methods that can be used to determine the value of the production decline exponent (b), one of which is: [14].

A. Loss Ratio Method (Arps)

According to J.J. Arps, the loss ratio method is a production decline curve extrapolation technique developed by Arps in 1945. This method uses the concept of a loss ratio, which is the ratio of the production rate at the end of a period to the amount of production decline during that period (q/(dq/dt)). This value is the inverse of the production decline rate and is usually presented in tabular form to aid the extrapolation process and identify the type of production decline curve.

B. Trial and Error Method

This method involves trying various values of the decline exponent (b) to estimate the production rate (q). Next, the difference between the actual production value (q_actual) and the predicted value (q_forecast) is calculated, and then the b value that produces the smallest difference between the two is selected. The importance of Web Plot Digitizer in DCA lies in its ability to convert graphical data into numerical data that can be used in analysis. Without tools like Web Plot Digitizer, the process of converting graphical data to numerical data would be time consuming and prone to human error. By using this tool, the digitization process becomes faster and more accurate, thereby increasing efficiency in oil reserve estimation. In addition, Web Plot Digitizer also makes it possible to process data from various sources, including annual reports and industry publications, which are often only available in graphical form. Decline curve analysis using the Arps equation is a proven and highly effective method for estimating well performance over time. This technique provides a reliable way to estimate future production rates based on historical data [15], [16].

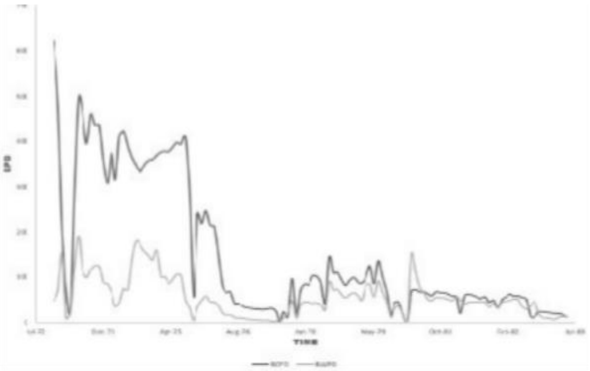
This research aims to apply Web Plot Digitizer in converting production graph data into numerical data, as well as determining oil reserves using Decline Curve Analysis. Through a case study in an oil field, it is hoped that insights can be gained into the effectiveness and efficiency of using Web Plot Digitizer in the context of the oil industry. The results of this research are expected to contribute to the development of a more accurate and data driven oil reserve estimation methodology.

MATERIALS AND METHODS

This study uses a descriptive quantitative method with a graphical approach that converts secondary data from the decline in production rate over time into numerical data as the first step in the reserve estimation process using decline curves. Production data from mature oil fields is presented graphically, with the x-axis representing time and the y-axis representing production rate, as shown in Figure 1. Decline Curve Analysis (DCA) is a commonly used method in petroleum engineering to analyze production trends and predict future production performance. By fitting a decline model to historical production data, engineers can estimate the Estimated Ultimate Recovery (EUR) of oil and gas wells.[17]

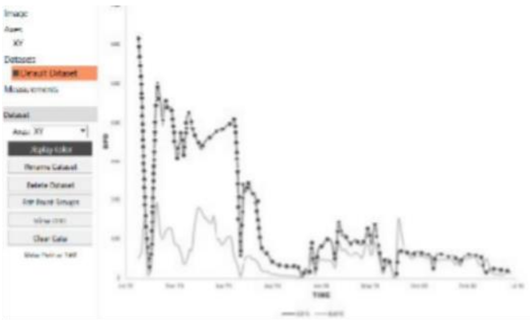
The production graph was converted into numerical data using Web Plot Digitizer with the following steps:

1. Upload the image of the production rate versus time graph into the Web Plot Digitizer application.
2. Calibrate the horizontal (time) and vertical (production rate) axes according to the graph scale. The x-axis represents the date/time from July 1, 1973, to July 1, 1983, and the y-axis represents production in barrels per day on a linear scale from 0 to 700 bpd.
3. Manually extract production rate data points using interpolation or smoothing to improve the reliability of the production data. The process of converting graphical data to numerical data using Web Plot Digitizer can be seen in Figure 2.
4. After the numerical data was successfully collected, it was saved in Microsoft Excel format. This facilitates further data processing and analysis, particularly during visualization. The next step was to plot the data on a semi-logarithmic (semilog) graph.



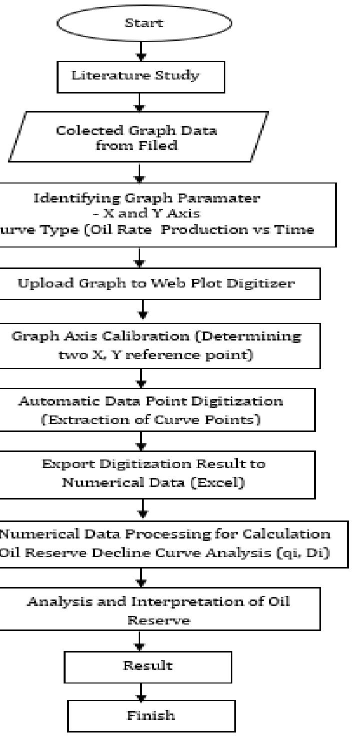
Source: (Research Results, 2025)
Figure 1. Production Graph of Old Oil Fields

This stage produces quantitative data on production rate versus time which forms the basis for the decline curve analysis. After the graphical data is converted into numerical data, oil reserves are determined using the J.J. Arps decline curve analysis method



Source: (Research Results, 2025)
Figure 2. The process of converting graphic data to numeric using the web plot digitizer.

After numerical data is successfully collected, it is saved in Microsoft Excel format. This facilitates further data processing and analysis, particularly during visualization. The next step is to plot the data on a semi-logarithmic (semilog) graph. . Figure 3 shows a flow chart research methodology.



Source: (Research Results, 2025)
Figure 3. Flow Chart Research Methodology

RESULTS AND DISCUSSION

This research aligns with various previous studies that applied Decline Curve Analysis (DCA) to estimate oil reserves in producing fields, although most of these studies were conducted assuming the availability of complete numerical production data. Similar studies have shown that exponential DCA can provide reliable Estimated Ultimate Recovery (EUR) estimates when historical data is available in digital tabular form.

However, these studies generally do not address the data limitations of mature fields, where production information is often only documented graphically. Unlike these conventional approaches, this study demonstrates that converting graphical data to numerical data using Web Plot Digitizer allows for quantitative exponential DCA implementation even when the original numerical data is unavailable. This finding has important implications for reactivation efforts for mature fields, as it opens up the possibility of evaluating reserves in fields that were previously difficult to

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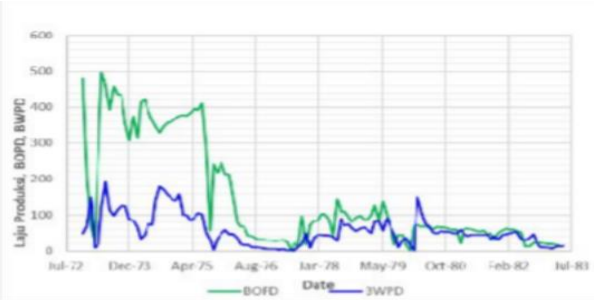
analyze due to data limitations. Without the use of digitization tools such as Web Plot Digitizer, reserve estimation in mature fields would rely heavily on the availability of digital archives or manual graph reading, which is subjective and less reproducible. Therefore, the approach used in this study can be a practical and economical alternative to support technical decision-making for reactivation of mature fields, while also expanding the utilization of historical production data, which has been suboptimal. The graph's x-axis represents time in years, while the y axis shows the production rate in barrels per day. The results of plotting the semilog graph can be seen in Figure 4. This graph provides a visual representation of the trend in oil production rates over time and serves as a basis for further analysis of field performance.



Source: (Research Results, 2025)

Figure 4. Graph of digitization results

Figure 5 shows a graph of the decline in oil production rates, which is used as a basis for forecasting future oil production. This graph is a crucial part of the analysis of oil production decline in a field. The method used in this forecast is decline curve analysis. This technique is commonly used in the oil industry to project remaining production based on historical patterns of production decline. Tang et al. demonstrated that selecting an appropriate DCA model significantly impacts Estimated Ultimate Recovery (EUR) estimation, highlighting the limitations of classical DCA when applied without considering production regime changes and operational interventions. This study strengthens the role of DCA as a reserve evaluation tool, but implicitly assumes the availability of complete, digital numerical data [11]

A study by J. Wiyono, A. Gafara Karim, and A. Sayyidina Putri applied Decline Curve Analysis to conventional oil fields to determine production decline parameters and reserve estimation. This study used available historical numerical production data and emphasized the validation of DCA results through the coefficient of determination (R^2) value. Their results showed that DCA, particularly the exponential model, is still relevant and effective for fields with relatively stable production patterns [13]. However, like the study by Tang et al., this study does not address conditions when numerical production data is unavailable and is only presented graphically.

Figure 5 explain the trend line for oil production decline in the graph is drawn from March 1980 to January 1981. This time period was chosen with particular consideration for the stability of other fluid production, particularly water. Water production during this period was recorded as relatively stable. This stability indicates that changes in oil production rates are not influenced by variations in water content, thus making the resulting graph more representative. Stable water production allows for a more accurate analysis of oil production decline. Therefore, data from this period is crucial in generating the decline curve. The exponential decline method was used to analyze the decline in oil production rates. The exponential decline method was chosen based on historical production data from the beginning of field development. The data shows that oil production rates have experienced a direct and consistent decline.

The production decline is detailed in Table 1. The table presents daily oil production figures, indicating a downward trend since the beginning of the analysis period. The red line in Figure 5 shows the results of applying the exponential decline method. This line represents the decline in oil production rates calculated from actual data. The red line plot is also used to determine the estimated remaining oil reserves in the field. This graph allows for more systematic and data- driven reserve analysis.

Table 1. Determination of Oil Production Rate Decrease

Date	BOPD
Mar-80	72.09.00
Apr-80	67.05.00
May-80	68.08.00
Jun-80	64.04.00
Jul-80	59.09.00
Aug-80	68.00.00
Sep-80	66.05.00
Nov-80	62.02.00
Dec-80	59.03.00
Jan-81	58.00.00

Source: (Research Results, 2025)

The results of converting production graphs into numerical data using Web Plot Digitizer demonstrate the tool's effectiveness in extracting data from historical graphs. In a case study of an aging oil field, a graph of production rate versus time, previously available only in visual form, was successfully converted into accurate numerical data. This process enabled further analysis of the

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production data, which was previously impossible due to the lack of data in numerical format.

Source: (Research Results, 2025)

Figure 5. Graph of the results of semilog scale digitization in determining oil reserves.

The numerical data obtained through the graph digitization process was used as the basis for creating a semilog graph of oil production rate versus time. This graph was created to facilitate the analysis of oil production trends in the field being studied. The use of a semilog graph is very helpful because it allows for the visual and systematic identification of production decline patterns. The results of the semilog graph indicate that the production decline pattern conforms to the exponential decline model.

This is evident from the trend line forming a straight line on the semilog graph, indicating that the rate of production declineis constant over time. This pattern aligns with the basic assumption of the exponential decline method, which states that there are no significant changes in reservoir pressure or fluid injection activity during the production period.

In this analysis, the data was adjusted to the exponential decline model using equations commonly used in petroleum engineering. The graph and calculations yielded an initial production rate (Qi) of 11.41barrels per day (bopd) and an exponent b of 0, indicating a pure exponential decline. Therefore, this method was deemed appropriate for describing the production behavior of the mature oil field studied. Furthermore, based on calculations using this method, the initial decline rate (Di) was found to be 0.041. This value indicates a relatively moderate initial rate of production decline, which was then used to calculate the total remaining oil reserves. From this analysis, the producible oil reserves were estimated at 5 million barrels of oil (5 MBO).

Web Plot Digitizer is a digital tool used to extract numerical data from graphs available in visual form. In petroleum engineering, this tool is crucial, especially in situations where historical oil production data is only available in printed graphs or digital images. This limitation is often encountered in mature oil fields, where management began long before digital recording was widely available. In the context of reservoir engineering, information on production rate over time is a crucial component for oil reserve analysis. When this data is not available in numerical form, manual or digital methods are required. Web Plot Digitizer addresses this need by enabling the conversion of graphical data into numerical format that can be further processed using production analysis software.

Decline Curve Analysis (DCA) is a very common method used to estimate oil reserves in fields that have been in production for a long time. This method analyzes the decline in production rate over time to project total future production. For this method to be implemented, historical production data in numerical form is required, making Web Plot Digitizer crucial in converting old production graphs into analyzable data. Using Web Plot Digitizer is an effective solution for converting graphs into numerical data, particularly when the original data is only available as graphic images. In petroleum engineering, particularly decline curve analysis, this becomes even more crucial in older fields without digital data

Production projections based on the exponential decline model revealed that the mature oil field was expected to reach the end of its production life in January 1985, unless production enhancement efforts such as workover or injection were undertaken. This information is detailed in Table 2 and serves as the basis for technical and economic considerations in the further management of the oil field. The graph has high resolution (300 dpi), the axes and annotations are clear, and the digitization is done with calibration and quality control so the error is small, and the digitized numerical data can be considered “close enough” to the original value.

In the case study of the mature oil field discussed, all available production data consisted only of a graph of production rate versus time. Using Web Plot Digitizer, the graph was successfully converted into accurate numerical data. This conversion allowed for replotting in the form of a semilog graph, which shows the relationship between production rate and time.

A semilog graph is a data presentation method frequently used in DCA, particularly to identify the appropriate decline model. In this case, the semilog graph shows a straight line pattern, indicating an exponential type of production decline. The exponential decline method was used because the production decline pattern aligns with the Arps

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assumption, which states that production rates decline exponentially in fields that do not experience fluid injection or pressure increase [18]. Using machine learning for reservoir production data analysis Including applications such as: production forecasting, well production optimization reservoir performance analysis [19].

Table 2. Results of Calculations for Determining Oil Reserves

Date	BOPD	Oil Cum. (Bbls
Apr-83	11.04	00.34
May-83	11.00	00.07
June-83	10.05	01.00
July-83	10.01	01.03
August-83	09.07	01.06
Sep-83	09.03	01.09
October-83	08.09	02.02
Nov-83	08.06	02.04
December-83	08.02	02.07
January-84	07.09	02.09
February-84	07.06	03.01
March-84	07.03	03.04
Apr-84	07.00	03.06
May-84	06.07	03.08
June-84	06.04	04.00
July-84	06.02	04.02
August-84	05.09	04.04
Sep-84	05.07	04.05
October-84	05.05	04.07
Nov-84	05.02	04.09
December-84	05.00	05.00
January-85	00.00	05.00

Source: (Research Results, 2025)

The analysis yielded an initial decline rate of 0.041, or 4.1% per month. This value indicates the rate of production decline since the beginning of the analysis period. With this information, future production can be projected using a mathematical formula consistent with the model in equation 1. This value is also crucial for calculating the remaining recoverable oil reserves from the field. Further calculations based on digitized data and decline analysis indicate that the cumulative recoverable oil production from the field is approximately 5 MBO (thousand barrels of oil). This figure represents the potential remaining production that can still be utilized if no additional interventions are made to the reservoir or production facilities.

However, based on the analyzed production decline trend, it is projected that production will reach its economic limit or even cease completely in January 1985 if no workover or reactivation efforts are undertaken. This information is crucial for decision-making regarding field redevelopment strategies. With the Web Plot Digitizer, the previously time-consuming and laborious process of manually reading graph data has become much more efficient. The resulting numerical data can be directly used in various petroleum engineering software for simulations, reserve estimation, or field economic evaluation. The benefits of using this tool extend beyond efficiency to increased data accuracy. Manual graph reading errors can be minimized with the Web Plot Digitizer's precision calibration and zoom features. This significantly helps ensure that the obtained numerical data accurately represents the production conditions occurring in the field.

In mature field development, data accuracy is crucial for the success of a reactivation strategy. Without accurate data, the risk of errors in reserve estimation or intervention design increases. Therefore, the use of technology like the Web Plot Digitizer is a crucial first step in workover planning or further development. Furthermore, this method also supports better data management practices in the oil and gas industry. Historical production data previously stored only in printouts or image files can be transformed into valuable digital assets and reused in various technical studies such as well performance evaluation or reservoir simulation.

Successful case studies demonstrating graphical conversion to numerical data, exponential decline modeling, and reserve estimation and production depletion projections demonstrate this tool's reliability as a key support tool in developing mature oil fields. The combination of Web Plot Digitizer for graphical data extraction and exponential decline curve analysis allows for realistic reserve estimates for mature fields with limited data. In the future, the use of this technology needs to be enhanced to enable more efficient and data-driven energy management

CONCLUSION

Web Plot Digitizer is used to convert graphical data to numerical data in determining oil reserves using the decline curve analysis method, especially in old oil fields where numerical data is not available only in the form of graphs. This study provides a scientific contribution by extending the application of exponential Decline Curve Analysis (DCA) to data-limited conditions, particularly when historical production data is only available in graphical form. By demonstrating that converting graphs to numerical data using Web Plot Digitizer produces data suitable for DCA analysis and fills a methodological gap in previous studies. Practically, this approach enables reserve estimation and production performance evaluation in mature oil fields without relying on complete digital numerical data, making it simple, economical, and easily replicable as a first step in technical decision-making in oil and gas asset optimization. In the future, this study opens up opportunities for further development through evaluating the uncertainty of digitization results, integrating automatic digitization and machine learning, and applying it to various reservoir types and other DCA models to improve the reliability of long-term production predictions. The existence of Web Plot Digitizer in the field of petroleum engineering helps develop old fields to calculate reserves so that old fields can be reactivated. In the case study of old oil fields that only have data available in the form of graphs with the help of web plot digitizer, numerical data will be obtained which is stored in Microsoft Excel, then a semilog graph of production rate versus time is created and the decline in production rate is analyzed using the decline curve method. The results of the decline curve analysis using exponentials obtained an initial decline rate (Di) value of 0.041 per month with oil reserves of 5 MBO where oil will run out in January 1985 if no workover is carried out on the field.

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